Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

ALASKA OREGON WASHINGTON
PACIFIC NORTH WEST
FOREST AND RANGE
EXPERIMENT STATION

· USDA FOREST SERVICE RESEARCH NOTE

PNW-289 February 1977

COMPUTER PLOTTING OF GRAPHS FOR REPORTS

by

Donald J. DeMars, *Forester*

and

Delbert E. Thompson, *Illustrator*

ABSTRACT

Computer plotting can aid forest scientists and forest land managers by increasing the speed and accuracy of graph preparation. This report outlines computer data requirements for common graph types and also gives computer data requirements for special plotting techniques.

Graphs that are included are (1) the equation graph, (2) the scatter diagram, (3) the combination equation graph and scatter diagram, (4) the line graph, and (5) the histogram. Although this paper is not a user's manual for a particular machine, it should be noted that a general plotting program is available for the Wang 700B - 720C programable calculators.

KEYWORDS: Computer plotting, graphs, histograms.

INTRODUCTION

The primary purpose of this paper is to anticipate that in the future most manuscript graphs likely will be drawn by machine; therefore, plotting data will have to be submitted in a standard format. Another purpose is to inform scientists and land managers of the capabilities and advantages of computer plotting and that a general plotting program exists for the Wang 700A - 720C programable calculator series.[1]

---

[1] The use of trade names and equipment in this paper shall not be construed in any way to be a recommendation or endorsement by U.S. Department of Agriculture, Forest Service.

OREST SERVICE - U.S. DEPARTMENT OF AGRICULTURE - PORTLAND, OREGON

This paper is not a user's manual for the Wang 700A - 720C programable calculator series. The plotting data requirements are general setup instructions that should be followed no matter what computer system is used. These instructions will help scientists and land managers communicate with the programer and will guide the programer when he is programing the problem for the computer.

A wide range of plots such as three dimensional surfaces, maps, powerline towers, logging systems, tree stem profiles, histograms, and various types of graphs have been drawn with the computer. This list is incomplete, but it exemplifies the capabilities of computer plotting.

Speed and accuracy are the main advantages of computer plotting. Machine-plotted graphs are produced in 10-15 minutes, and accuracy is limited only by the input data and the resolution of the plotting device. (The resolution of the plotting device is usually inconsequential.) If a graph is similar to the common types presented in this report and the data are submitted as requested, the scientist or land manager need not spend much time producing highly accurate graphs for manuscripts.

A short discussion of the organization of this paper is necessary before examples of the most common types of graphs and their specific data requirements are presented. The report has three parts: (1) general plotting information required for all graphs, (2) common graph types and their individual data requirements, and (3) special plotting techniques.

Normally, only the data requirements given in parts 1 and 2 are considered for a common graph type. Part 3 deals with special plotting techniques that scientists or land managers occasionally might use when presenting data or results in graphic form. Any combination of the special plotting techniques can be used on a single graph.

Occasionally, two or more of the common graph types from part 2 are combined to form a single graph. When this occurs, the specific data requirements for each graph type in the combination must be met before the combination graph can be drawn.

GENERAL PLOTTING INFORMATION REQUIRED FOR ALL GRAPHS

There are four distinctive line types: (1) solid line, (2) dash line, (3) dotted line, and (4) the dash-dot line. These line types are the ones most used when plotting; however, additional line types can be created by varying the length of the dashes in the dash and dash-dot lines. It is recommended that no more than six line types be used on any one graph.

For computer plotting, five symbols are used. They are:

(1) dot . ,

(2) plus + ,

(3) square □ ,

(4) hexagon ⬡ (this looks like a circle when plotted), and

(5) triangle △.

For scattered diagrams and other graphs that require the plotting of individual data points, it is recommended that the data be on standard 80-column computer cards. The x and y variables must appear on the computer card in the same format for any given batch of data; however, the format can be varied from one batch to another. For each batch, the card columns that the x and y variables occupy must be indicated along with the proper placement of decimal points. If the data are not on cards, a list of the x and y coordinates will be adequate.

The plotting data needed irrespective of graph type are:

(1) type of graph to be plotted,
(2) publication figure number,
(3) figure label,
(4) length of the x-axis in inches (maximum length allowed is 12 inches),
(5) length of the y-axis in inches (maximum length allowed is 8 inches),
(6) minimum value on the x-axis scale (if an axis has nonsequential numbering, letters, or special labels, submit an example of the axis. Designate the axis as shown on the General Plotting Information Form in the appendix.),
(7) maximum value on the x-axis scale,
(8) scale interval for the x-axis scale,[2]
(9) minimum value on the y-axis scale,
(10) maximum value on the y-axis scale,
(11) scale interval for the y-axis scale (see footnote 2), and
(12) axis labels.

The General Plotting Information Form in the appendix was created to facilitate the recording of general plotting data. This form outlines the general plotting information required of all graphs.

COMMON GRAPH TYPES AND THEIR INDIVIDUAL DATA REQUIREMENTS

Equation Graph

Frequently, in the course of a research study, an equation is developed that relates one dependent variable with one or more independent variables. When such an equation is published, a graph of the equation is often included to help the reader understand the results.

The number of independent variables present in an equation determines whether the graph will be a single curve or a family of curves such as shown in figure 1. The single curve is produced by varying only the x-axis variable when solving for the corresponding y-axis values. A family of curves is produced when the x-axis variable is varied for different levels of a second independent variable. In figure 1, the height equation (Curtis et al. 1974) was solved for various ages while site index was held at given levels.

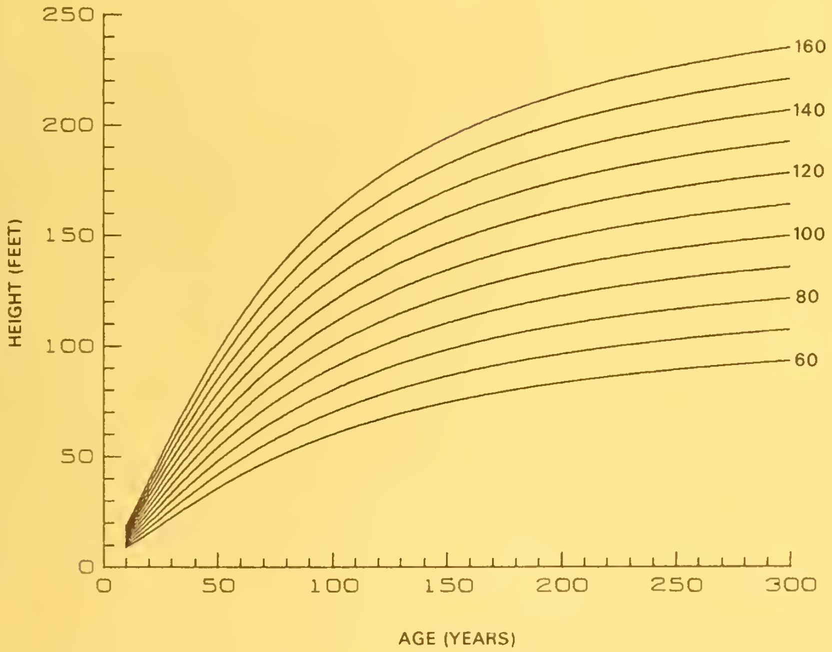


Figure 1.--Equation graph. Height growth curves for Douglas-fir.

---

[2] Scale intervals may be adjusted by the illustrator.

Together with the general plotting information, specific data needed for an equation graph are:

(1) The equation should be in a form such that the y-axis value is easily calculated when numerical values are substituted for the independent variables. The form is: y-axis value = (some algebraic expression).

(2) The x-axis variable must be identified, and the minimum and maximum values to be substituted in the equation must be given.

(3) If a second independent variable is also used, identify the variable and list the values to be substituted for it in the equation.

(4) Designate the type of line desired.

(5) Provide labels if curves need to be identified.

If more than one equation is to be plotted on a graph, the preceding information must be given for each equation on the graph. It should be noted that the scientist need not solve an equation for plotting points.

Scatter Diagram

The specific data needed for a scatter diagram are:

(1) The x-y coordinate values for a each data point--if this information is available on computer cards, submit a data deck;

(2) The type of symbol to be used when plotting a group of data points--this especially is important when several groups of data are plotted on one graph; and

(3) Any labels to be used for identifying the groups of data.

Figure 2 is an example of a scatter diagram that has three data groups represented.

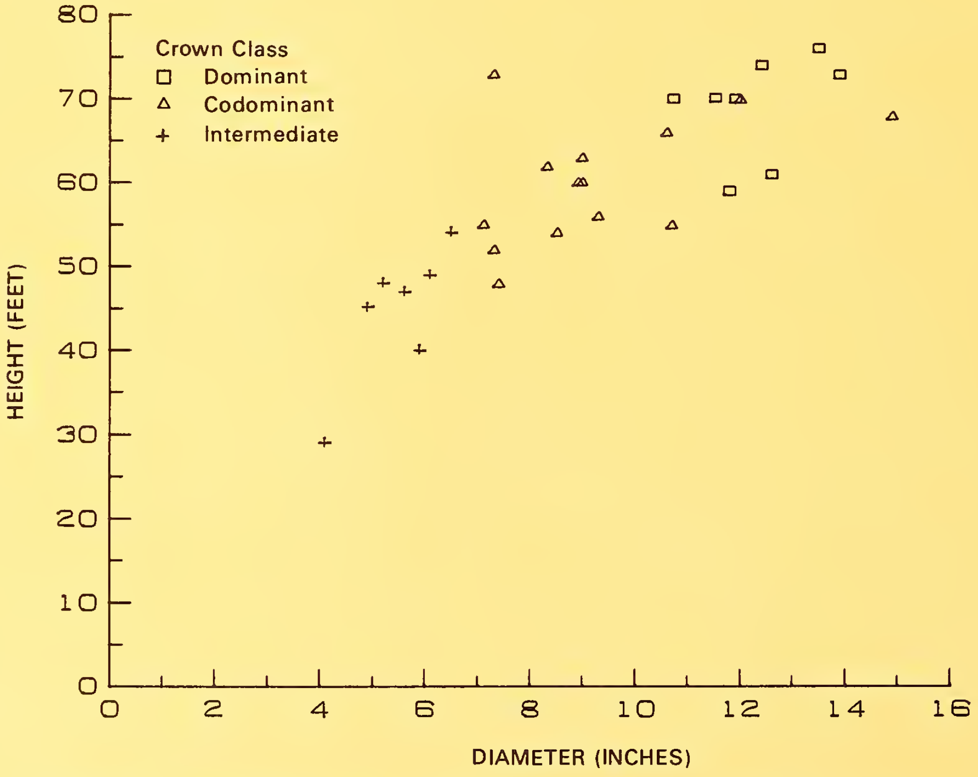


Figure 2.--Scatter diagram. Height-diameter relationship for a ponderosa pine stand by crown classes.

Combination Equation Graph and Scatter Diagram

Data needed for this graph are the combination of the data required for an equation graph and the data required for a scatter diagram. Usually, this type of graph is used for comparing a regression equation to the data from which it was derived, as is shown in figure 3 (Rothacher 1973). Plotting data for figure 3 are given in the appendix as an example of how plotting data should be set up for computer plotting.

Histograms

There are many types of histograms as illustrated by figures 4, 5, and 6; however, they all have the same data requirements. Items needed to draw histograms are:

(1) The number of bars to be centered around an x-axis scale value (see examples),

(2) A sketch of the x-axis (General Plotting Information Form),

(3) The y-axis scale value of each histogram bar along with the bar's position on the x-axis, and

(4) Bar labels, if needed.

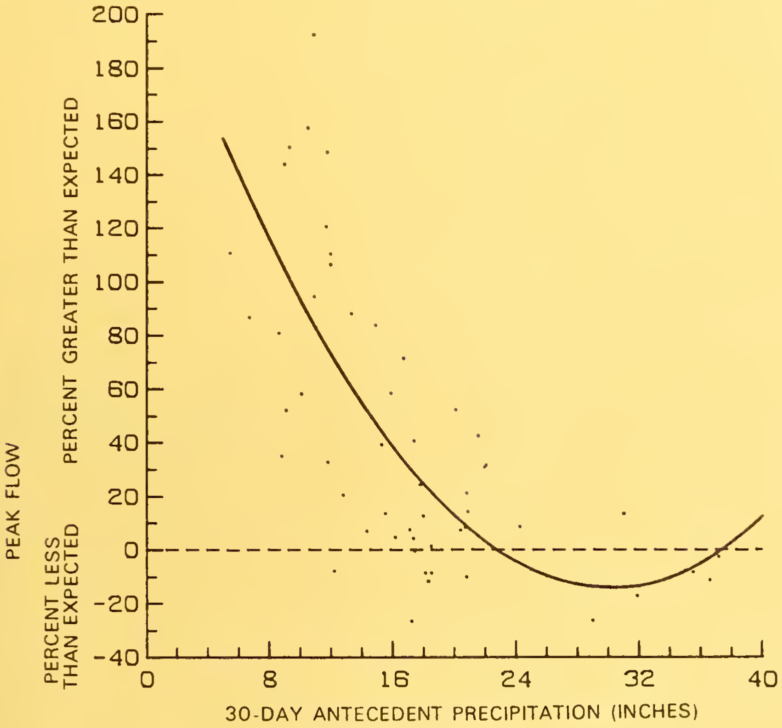


Figure 3.--Combination equation graph and scatter diagram. Figure title from Rothacher (1973) was: "Measured peak streamflow as a percent of predicted peak at various degrees of wetness as expressed by 30-day antecedent precipitation."

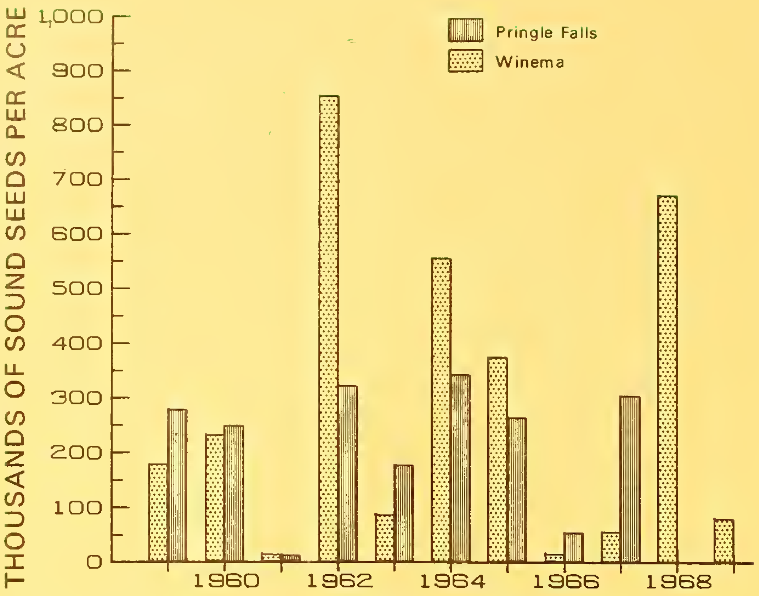


Figure 4.--Histogram--Two bars centered on each x-axis scale value (from Dahms and Barrett 1975, reproduced with permission). Figure title as it appeared in Dahms and Barrett, "Number of sound lodgepole pine seeds per acre on the Winema and Pringle Falls areas."

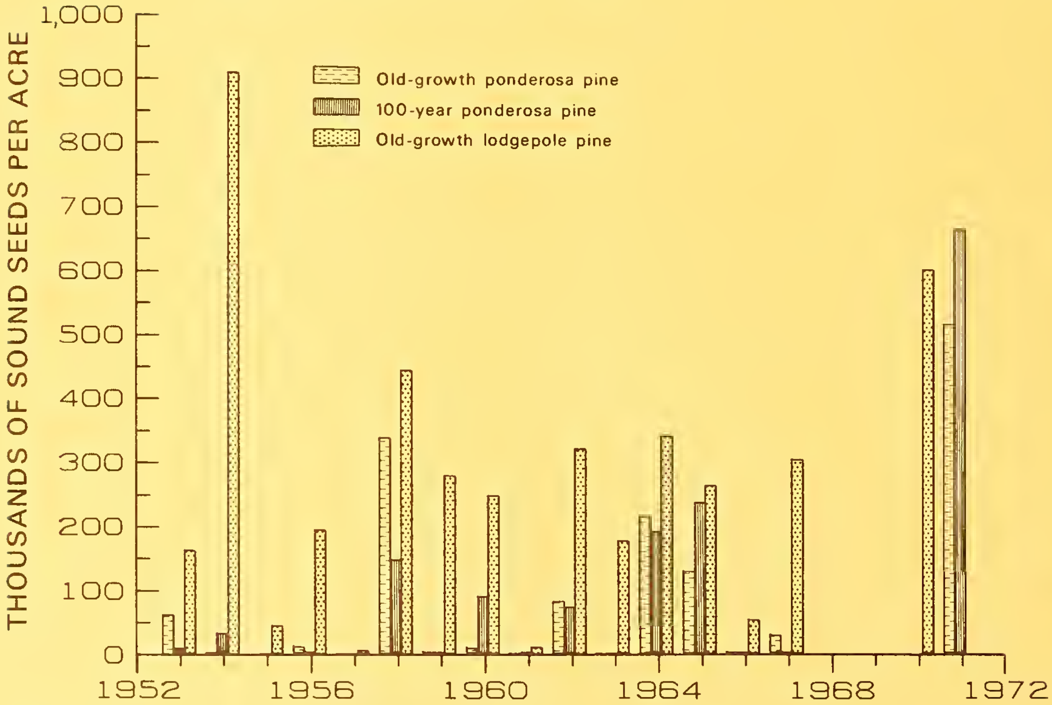


Figure 5.--Histogram--Three bars centered on each x-axis scale value (from Dahms and Barrett 1975, reproduced with permission). Figure title as it appeared in Dahms and Barrett: "Sound seeds per acre by year for old-growth ponderosa pine, 100-year ponderosa pine, and old-growth lodgepole pine. Pringle Falls study (data missing for 1968, 1969, 1970, and 1971 were destroyed by the 1974 fire at the Silviculture Laboratory in Bend)."

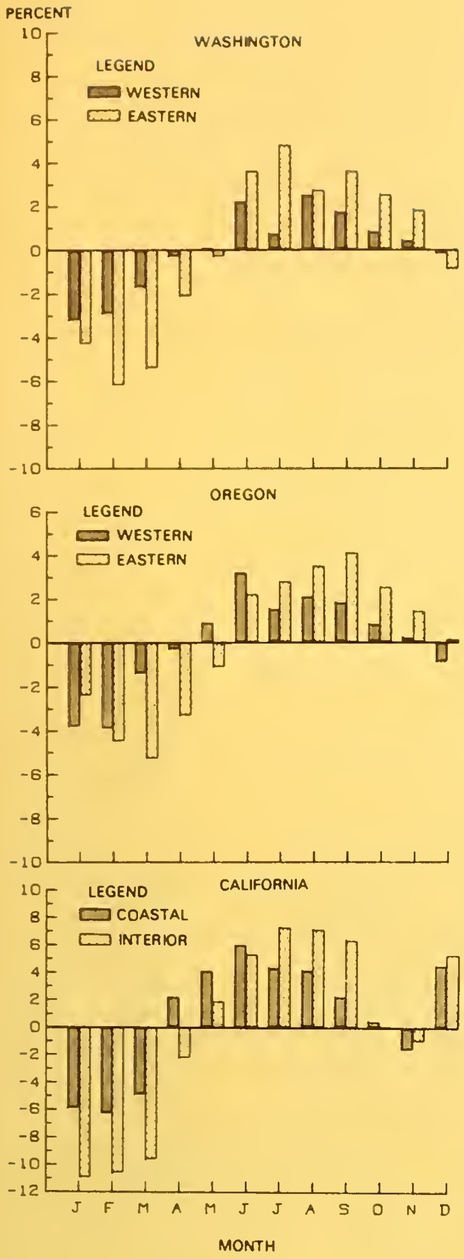


Figure 6.--Histograms--Two bars centered on each x-axis scale value. The zero value of the y-axis is not located at the origin of the graph. Also, this graph is an example of graph stacking. (From Wall and Oswald 1975, reproduced with permission.) Figure title as it appeared in Wall and Oswald, "Monthly deviations from average employment in sawmills and planing mills in Washington, Oregon, and California, 1969-71."

Line Graphs

Figure 7 (Hickman 1975) is an example of a line graph that shows trends for various data groups. Each line on the graph is made up of individual data points connected by straight lines. Data to be supplied for each line on the graph are:

(1) The x-y coordinates for the individual data points that make up the line. If this information is on computer cards, submit a data deck;

(2) The type of line to use between data points;

(3) Symbol to be used for the data points; and

(4) Labels to be used for line identification.

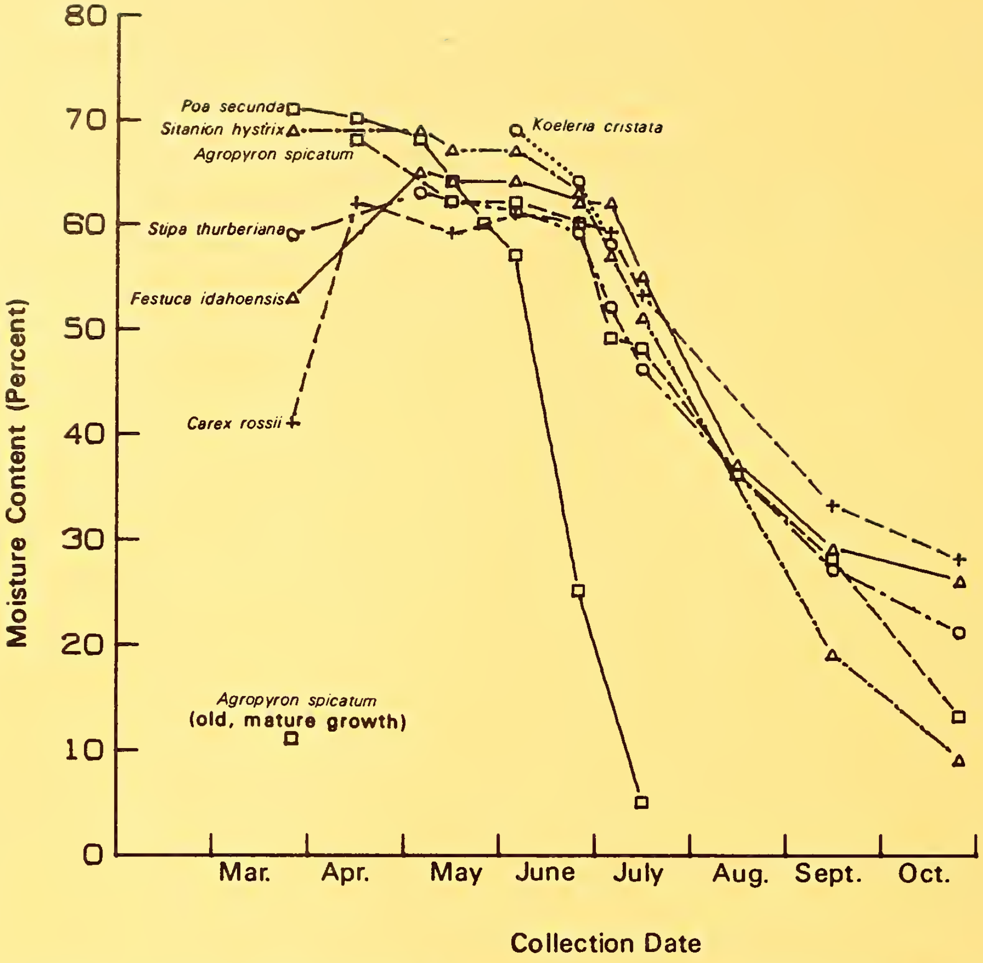


Figure 7.--Line graph (from Hickman 1975, reproduced with permission). Figure title as it appeared in publication, "Seasonal moisture trends in herbaceous species."

SPECIAL PLOTTING TECHNIQUES

Special plotting techniques are used to save space and to present graphs more effectively. The graphs presented in this section are the results of computer plotting, hand touchup, cutting, pasting, and photocopying. These graphs illustrate that, with a minimum of handwork, computer plots can be altered or combined to present results in various ways.

Second y-axis Scale

Sometimes a second y-axis scale is needed on a graph to facilitate a special set of data as shown in figure 8 (Hickman 1975) or to show results in metric units. Data needed for such cases are:

(1) Length of second y-axis in inches,
(2) Minimum scale value to appear on the second y-axis,
(3) Maximum scale value to appear on the second y-axis,
(4) Scale interval desired on the second y-axis,
(5) Axis label,
(6) Any data to be plotted using the second y-axis scale, and
(7) Data labels.

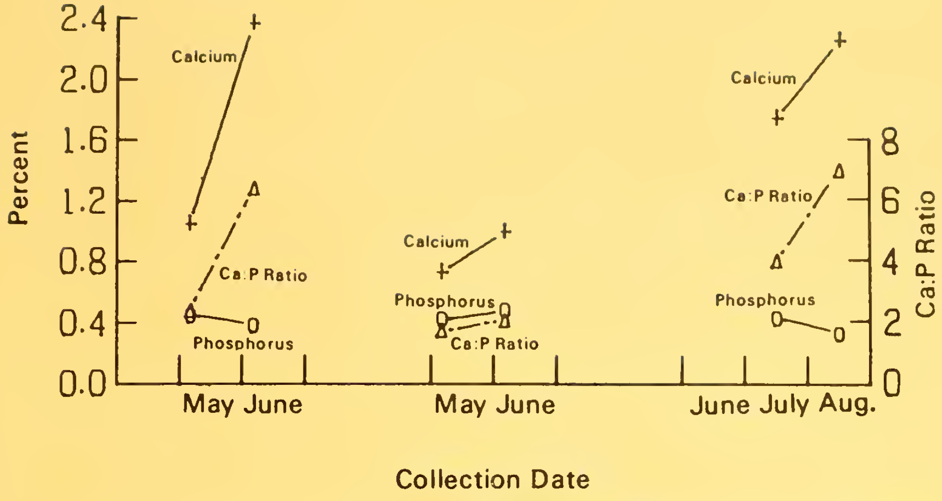


Figure 8.--Second y-axis scale (from Hickman 1975, reproduced with permission). Figure title as it appeared in publication, "Seasonal trends of constituents in tall western senecio, mountain lily, and Oregon sidalcea."

Break Lines in Axes

If a graph (fig. 9, Wall and Oswald 1975) has break lines in any of its axes, a sketch of the axis should be given along with the other plotting data. The sketch can be drawn on the General Plotting Information Form and must include:

(1) The location of all break lines and

(2) The scale values desired on each side of a break line.

Stacked Graphs

Stacked graphs, as shown in figures 10 and 11, are possible only if the x-axis is the same for all the graphs to be stacked. The data needed for graph stacking are:

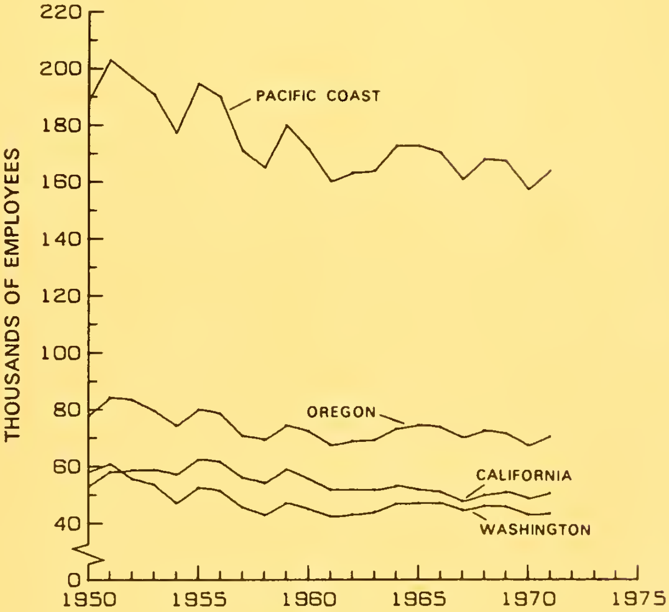


Figure 9.--Break line in axis (from Wall and Oswald 1975, reproduced with permission). Figure title as it appeared in publication, "Average annual employment in the lumber and wood products industry on the Pacific coast by State, 1950-71."

(1) A sketch of the stack (use General Plotting Information Form),
(2) The number of graphs to be stacked (recommended limit = 4),
(3) The order of stacking, and
(4) The plotting data for each graph in the stack.

Logarithmic Plotting

Converting data to logarithms (base 10) and plotting the transformed data on logarithmic scales can be done on the computer. Common graph types that are sometimes plotted in logarithms are the equation graph, scatter diagram (fig. 12), and combination equation graph-scatter diagram. Designation of the x- or y-axis, or both, is necessary for logarithmic plotting.

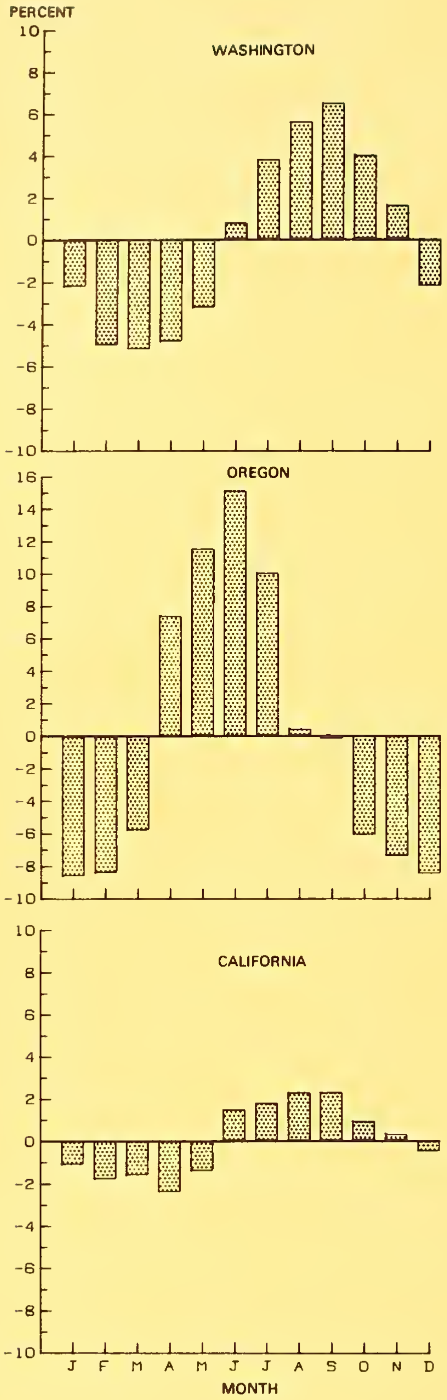


Figure 10.--Stacked histograms (from Wall and Oswald 1975, with permission). Figure title as it appeared in publication, "Monthly deviations from average employment in the paperboard container and box industry in Washington, Oregon, and California, 1969-71."

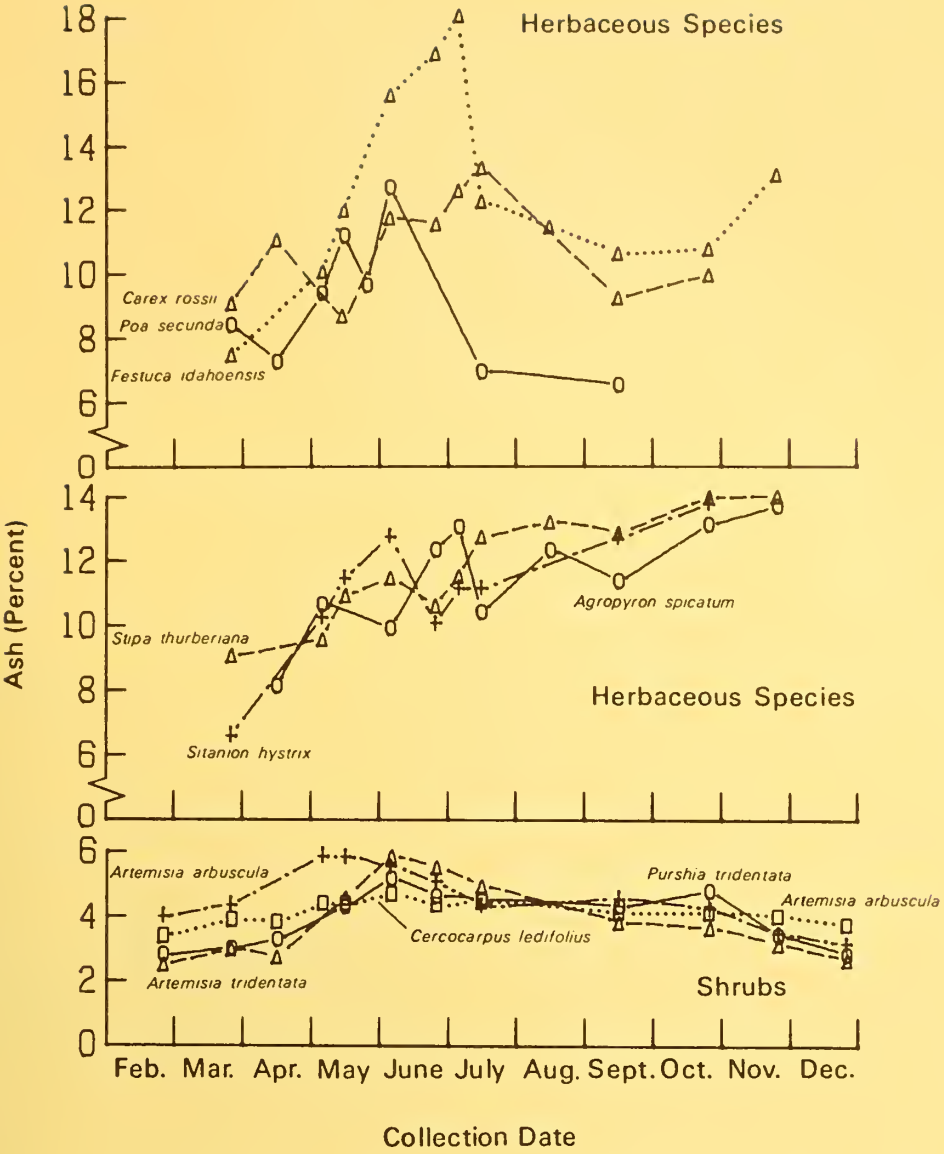


Figure 11.--Stacked line graphs (from Hickman 1975, reproduced with permission). Figure title as it appeared in publication, "Seasonal trends of ash (total mineral matter)."

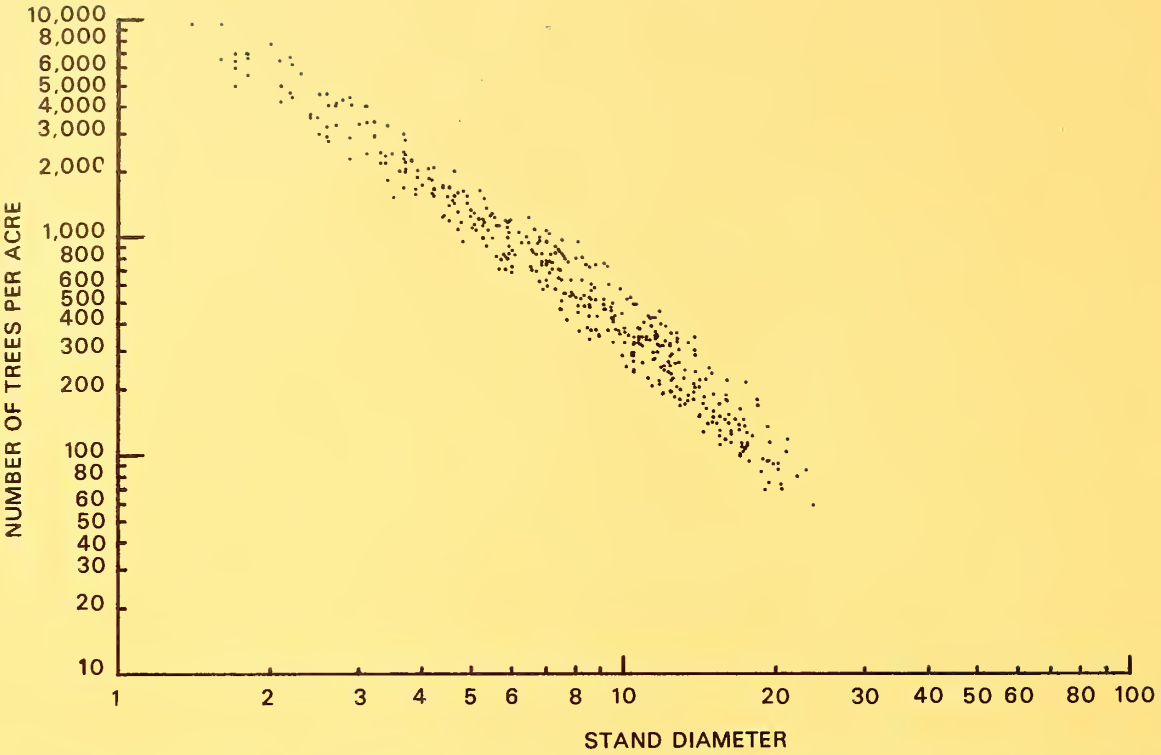


Figure 12.--Number of ponderosa pine trees per acre over average stand diameter plotted on logarithmic scales.

SUMMARY

Drawing graphs by computer can aid forest research scientists and forest land managers in data analysis and in report preparation. Many graphs of high quality can be drawn in a few minutes at a fraction of the cost of hand-drawn graphs.

To take advantage of computer plotting, the scientist or land manager must be able to communicate with the programer doing the plotting. This paper outlines information a programer would need to plot certain types of graphs and gives a format for organizing plotting information.

The types of graphs presented are (1) the equation graph, (2) the scatter diagram, (3) the combination equation-graph and scatter diagram, (4) the line graph, and (5) the histogram. Data requirements for each graph are given, and at least one example of each graph is presented. In addition, special plotting techniques such as stacking graphs, breaking lines on the axis, a second scale for the y-axis, and logarithmic plotting are explained and shown.

It should be noted that a general plotting program was written for the Wang 700A - 720C programable calculator series. The plotting data requirements are general setup instructions that should be followed no matter what computer system is used for the plotting.

LITERATURE CITED

Curtis, Robert O., Francis R. Herman, and Donald J. Demars.
1974. Height growth and site index for Douglas-fir in high-elevation forests of the Oregon-Washington Cascades. For. Sci. 20:307-316, illus.

Dahms, Walter G., and James W. Barrett.
1975. Seed production of central Oregon ponderosa and lodgepole pines. USDA For. Serv. Res. Pap. PNW-191, 13 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Hickman, Eugene O.
1975. Seasonal trends in the nutritive content of important range forage species near Silver Lake, Oregon. USDA For. Serv. Res. Pap. PNW-187, 32 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Rothacher, Jack.
1973. Does harvest in west slope Douglas-fir increase peak flow in small forest streams? USDA For. Serv. Res. Pap. PNW-163, 13 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Wall, Brian R., and Daniel D. Oswald.
1975. A technique and relationships for projections of employment in the Pacific coast forest products industries. USDA For. Serv. Res. Pap. PNW-189, 49 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

APPENDIX

General Plotting Information Form

Name of publication *Computer Plotting of Graphs for Reports*

Author(s) *Donald J. DeMars and Delbert E. Thompson*

Figure No. *3*

Figure label *Combination Equation Graph and Scatter Diagram*

Type of graph: Equation ☐ Scatter diagram ☐

Combination equation and scatter diagram ☒

Histogram ☐ Line graph ☐ Part of a combination ☐

Length of axis: x axis *5.5 inches* y axis *6.0 inches*

Axis scale values: x-axis min. *0* x-axis max. *40*

x-axis scale interval *8*

y-axis min. *-40* y-axis max. *200*

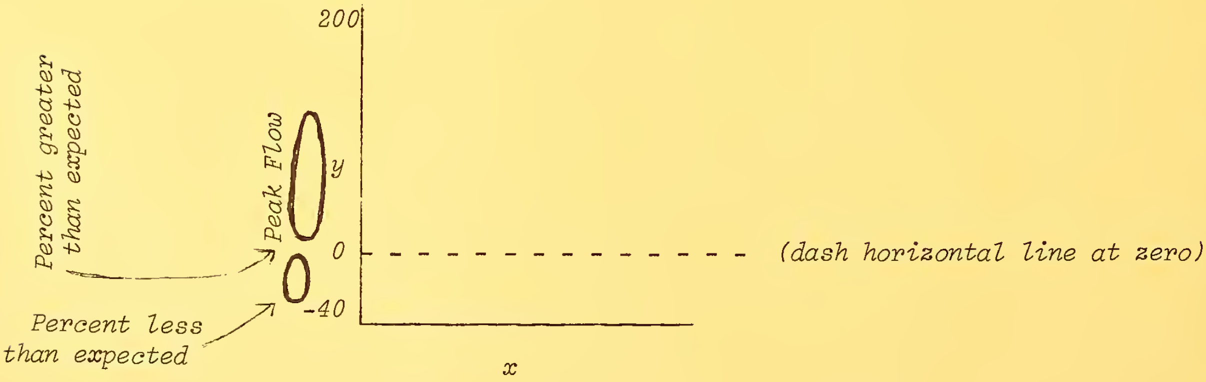
y-axis scale interval *20*

Axis labels: x-axis *30-day antecedent precipitation (inches)*

y-axis *Peak Flow*

Percent less than expected Percent greater than expected

Axis and/or data sketch if needed:


200
Percent greater than expected
Peak Flow
y
0
-40
Percent less than expected
x
(dash horizontal line at zero)

Example of xy coordinates for figure 3:

x	y	x	y
9.3	150.4	18.0	-9.0
17.8	23.7	18.5	-8.5
18.0	12.0	8.7	35.2
20.8	-10.9	10.9	95.0
24.3	9.0	17.3	3.8
21.9	31.1	16.6	71.8
31.9	-17.8	10.8	192.8
37.2	-2.3	11.8	148.3
35.4	-9.0	8.9	143.7
36.6	-12.1	12.8	20.3
30.9	13.8	8.5	81.2
28.9	-26.8	11.8	32.5
22.0	31.8	11.6	121.2
15.2	39.5	12.2	-8.1
6.6	86.7	10.0	58.6
14.9	83.1	14.3	6.8
16.2	4.1	17.4	41.0
20.8	21.3	17.1	-27.0
9.0	52.2	17.0	8.0
5.3	110.8	15.4	14.0
10.5	157.7	18.5	1.0
12.0	105.7	18.2	-12.0
13.3	88.5	20.9	14.0
15.9	58.2	21.6	43.0
20.7	8.1	20.3	7.0
20.0	52.7	17.9	-1.0

Type of symbol: dot

Example of equation for figure 3:

$y = 227.52176 - 16.147861(x) + 0.2693494(x^2)$

where: y = Peak flow in percent

x = 30-day antecedent precipitation

Minimum value of $x = 4$

Maximum value of $x = 40$

Type of line--solid

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research are made available promptly. Project headquarters are at:

Fairbanks, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington

Mailing address: Pacific Northwest Forest and Range
Experiment Station
P.O. Box 3141
Portland, Oregon 97208

GPO 998-050

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

The U.S. Department of Agriculture is an Equal Opportunity Employer. Applicants for all Department programs will be given equal consideration without regard to race, color, sex or national origin.